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tatory reaction which drives water in one direction.[2] But some of his reasoning is radically defective, the chapters are full of assumptions, and his experiments are inconclusive. Indeed, he hardly seems to know how difficult a problem he is attacking, and he goes at it with the naïveté of a novice. Such work really tends to prejudice one against the whole book; and caution *is* necessary, for there are other weak spots. In spite of these, the suggestiveness, the ingenuity, and the enormous labor displayed impel us to give this book a most cordial reception. And we shall await with much interest a promised volume on the electrophysiology of plants.—C. R. B.

MINOR NOTICES.

N. Am. Uredineae.—The second part of HOLWAY'S photomicrographs of plant rusts[3] has just appeared, having been delayed several months by a printer's strike. The general character and purpose of this publication were described in this journal[4] upon the appearance of the first part. The present part continues the genus Puccinia through eleven host families, ending with Rosaceae. The photogravure plates carry out fully the promise of the first part.—J. M. C.

Schneider's Handbuch.—The fifth part of the *Illustriertes Handbuch der Laubholzkunde*[5] concludes Drupaceae and includes Pomaceae, and ends the first volume. There are 128 text figures, and a volume index of genera.—J. M. C.

NOTES FOR STUDENTS.

The ascent of water.—After GODLEWSKI'S interesting theory of the relay-pump action of the medullary rays in lifting water seemed to have been completely overthrown by STRASBURGER,[6] who found water still ascending for weeks after treatment calculated to kill living cells, the participation of living cells in lifting water found a champion on theoretical grounds in SCHWENDENER.[7] But PFEFFER[8] hardly dared more than to suggest that they might be of importance in the maintenance of normal conditions in the conducting tissues. Then URSPRUNG rallied to the support of SCHWENDENER with experimental work, and in a paper published two years ago[9] contended that the living cells, either by maintaining the conducting system in condition or by actually lifting, had an important share in the ascent of water. His experiments were carried out on small plants mainly, and he ventured no generalization.

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[2] See in this connection reviews of other recent papers below.

[3] HOLWAY, E. W. D., North American Uredineae, Vol. I. part II. 4to. pp. 33–56. *pls. 11–23.* Minneapolis, 1906. $2.00.

[4] BOT. GAZETTE 40:459. 1905.

[5] SCHNEIDER, CAMILLO KARL, Illustriertes Handbuch der Laubholzkunde. Fünfte Lieferung. Jena: Gustav Fischer. 1906. *M* 4.

[6] STRASBURGER, E., Ueber den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen. Histologische Beiträge 3. Jena, 1891. Ueber das Saftsteigen. Histologische Beiträge 5. Jena, 1893.

[7] SCHWENDENER, S., Zur Kritik der neuesten Untersuchungen über das Saftsteigen. Sitzb. Berliner Akad. 44:911–946. 1892. Gesammelte Unters. 1:256–297. Weitere Ausführungen über die durch Saugung bewirkte Wasserbewegung in der Jamin'schen Ketten. Sitzb. Berliner Akad. 45:835–846. 1893. Gesammelte Unters. 1:298–315. 1898.

[8] PFEFFER, W., Pflanzenphysiologie 1:203. 1897.

In a more recent paper[10] he reviews critically the direct and incidental experiments of others on this subject, replies to objections raised against his earlier paper; and details further experiments intended to ascertain the precise rôle of living cells. The author adopts a rather hypercritical attitude toward previous results, as is well illustrated by this reasoning regarding girdling: "If at the base girdling 1^{dm} long is borne without injury, it does not signify that this would be the case also at the apex; and if girdling 1^{dm} long does not interrupt the conduction of water, it is not proved that this would not occur with girdling one or two meters long. Hence it follows that the bark (*Rinde*) must be entirely removed if one wishes to form a judgment as to its share in the ascent of sap; and even then one can at most only recognize that it may be dispensed with—not that under ordinary conditions it takes no part in the ascent of sap."

By liberal discounts URSPRUNG arrives at the conclusion that *all* previous researches on this point speak in favor of the participation of living cells in raising water. Even the experiments of STRASBURGER, which have been interpreted as flatly contradictory to such an idea, are counted as offset by his finding that the leaves die after one actually kills 10^{cm} of the stem. For, according to URSPRUNG, the cooperation of living cells throughout the entire length of the plant is necessary; but a small fraction of the conducting system suffices to supply water if in this region the wood cells are living; whereas the whole is inadequate to furnish enough water when they are killed. These living cells do not merely keep the conducting tissues in good condition; they "cooperate in the production of the lifting force," and the component which they furnish is of great significance in comparison with the "purely physical." A notable exception is the beech, in whose older parts the cells of the bark are without influence, "and even in the youngest parts such interaction is insignificant." It is hard to conceive how the living cells in the bark, being outside the water paths, can participate in the work of raising water, and harder still to imagine that they do so in certain plants and not in others.

STEINBRINCK attacks the problem from the "purely physical" side,[11] and seeks to extend our knowledge of hydrodynamics. He examined the cohesion of water by means of the supersiphon, i. e., a siphon whose legs are so long as to permit the use of columns of liquid too high to be raised by atmospheric pressure, to which (STEINBRINCK thinks erroneously[12]) the action of the common siphon is ascribed. He attempted to ascertain the cohesion of water under various conditions, and met sometimes with such capricious behavior of his apparatus that, more than ever by this experience, he is convinced of the necessity for much more extended physical knowledge before the problem of the ascent of sap can be solved. The reinvestigation of the tension of gases in fern and other sporangia (which he finds nearly at atmospheric pressure) and of their disappearance when the sporangia are wetted, shows that these phenomena do not fall in with any known physical laws; and as these structures plainly contain only dead cells the problem cannot be obscured by dragging in "vital activities" and remains at present inexplicable. How much more caution, then, is needed in the more complex problem of sap movement!

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[9] URSPRUNG, A., Untersuchungen über die Beteiligung lebender Zellen am Saftsteigen. Beihefte Bot. Cent. **18**:145–158. 1904.

[10] ——————, Die Beteiligung lebender Zellen am Saftsteigen. Jahrb. Wiss. Bot. **42**:503–544. 1906.

[11] STEINBRINCK, C. Untersuchung über die Kohäsion strömender Flussigkeiten mit Beziehung auf das Saftsteigeproblem der Bäume. Jahrb. Wiss. Bot. **42**:579–625. 1906.

STEINBRINCK finds that a water filament 2^{mm} thick, moving at the rate of 2^{cm} per second, bears a pull of four atmospheres, its tensile strength increasing with diminishing size and rate of flow. Such filaments bear even violent shaking, under certain conditions, without rupture. Their stability is not affected by extremes of temperature that would be encountered in the growing season (say 0° to 35° C.). By ingenious experiments he shows that cohesion may act through membranes, such as the partitions that interrupt the tracheae. As for the objection to the cohesion theory on account of the Jamin-chain condition, he suggests caution on account of deficient physical knowledge, enforcing this by citing the case of gas absorption in the opening sporangia already alluded to. He does not deny the participation of living cells, but can form no conception of the manner in which they act.

EWART, recognizing that water is a liquid of definite viscosity and that the channels through which it moves are small, thereby offering great resistance, has endeavored to ascertain the amount of this resistance in definite cases, and the possible means by which is generated the force necessary to raise water at the required rate.[13] He finds that the flow of water through open vessels is in accord with POISEUILLE'S formula deduced from flow through rigid tubes; hence the velocity is proportional to the pressure and to the square of the radius of the tube, and inversely proportional to the length of tube and viscosity of the liquid. The total resistance in erect stems corresponds to a head of water 6 to 33 (for shrubs and small trees) or 5 to 7 (for large trees) times the height of the plant. Hence, in the tallest trees, the pressure required may be as much as 100 atmospheres. The maximal osmotic suction of leaves in an elm 18^{m} high was 2–3 atmospheres, with a total resistance to flow in the trunk of 10–12A. "It appears, therefore," concludes EWART, "that to maintain flow, a pumping action of some kind or other must be exercised in the wood, for which the presence of active living cells is essential. . . . . There is no known means by which these cells can directly pump water in a definite direction. . . . . It is suggested that the wood parenchyma cells, by the excretion and reabsorption of dissolved materials, may bring into play surface tension forces within the vessels of sufficient aggregate intensity to maintain a steady upward flow, and to keep the water of the Jamin's chains in the vessel in a mobile condition, ready to flow to wherever suction is exercised."

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[12] STEINBRINCK, C. Ueber dynamische Wirkung innere Spannungsdifferenzen etc. Flora **93**:127–254. 1904.

[13] EWART, A. J., The ascent of water in trees. Phil. Trans. Roy. Soc. London B. **198**:41–85. 1905.

But STEINBRINCK declares himself (*l. c.*) unable to form any conception of how such an action can be produced, and LARMOR objects[14] on purely mechanical grounds, saying: "If the osmotic gradient, assisted by capillary pull at the leaf orifices, is insufficient to direct a current of transpiration upward, *capillary* alterations inside the vessels, arising from vitally controlled emission and absorption of material from the walls cannot be invoked to assist." He suggests that *osmotic* changes in the vessels, of peristaltic character, might do; but he apparently does not know that osmotic phenomena do not occur in sap vessels. As a physicist, he inquires whether there is a sufficient stock of energy in the stems for the pumping work required; and he renews the eminently plausible suggestion that the work is done where the external energy is received, viz., in the leaves.

It cannot be said that these researches have solved the problem of water movement. But each in its own way has added something to our knowledge. The more hopeful lines seem to be in determining physical factors and studying more closely the dynamics of the question.—C. R. B.

Gymnosporangium galls.—The anatomical changes induced by *Gymnosporangium clavariaeforme* and *G. juniperinum* on the twigs and leaves of their host, *Juniperus communis*, have been investigated by LAMARLIÈRE[15] with the following main results. The mycelium of *G. clavariaeforme* inhabits the cortex and phloem regions, but does not penetrate into the wood. The cells of the cortex are multiplied and enlarged so that all lacunae are obliterated, resulting in a general hypertrophy of this region. The formation of collenchymatous tissue is almost entirely suppressed. In the phloem region the medullary rays undergo the most marked transformation. Not only do the rays themselves become more numerous, but the cells composing them are also greatly increased in number, so that this tissue is likely to make up about one-half the volume of the bast region. The sieve tubes, parenchyma, and bast fibers retain their normal succession, but owing to the great increase in parenchyma from the rays and from the increased volume of the bast parenchyma, the course of the sieve

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[14] LARMOR, J., Note on the mechanics of the ascent of sap in trees. Proc. Roy. Soc. B. **76**:460–3. 1905.

[15] LAMARLIÈRE, L. GÉNEAU DE, Sur les mycocécidies des Gymnosporangium. Ann. Sc. Nat. Bot. IX. **2**:313–350. *pls. 8–12.* 1905.